Signals and Circuits

ENGR 35500

Current, Voltage, Resistance and power

Chapter 1 Circuit Terminology: 1-5 (Voltage and Power), 1-6 (Circuit elements); Chapter 2 Resistive circuit: 2-1 (Ohm's law)

Ulaby, FawwazT., and Maharbiz, Michael M., Circuits, 2nd Edition, National Technology and Science Press, 2013

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Resistance?

The medium of the current flow impedes the flow speed.

Resistance

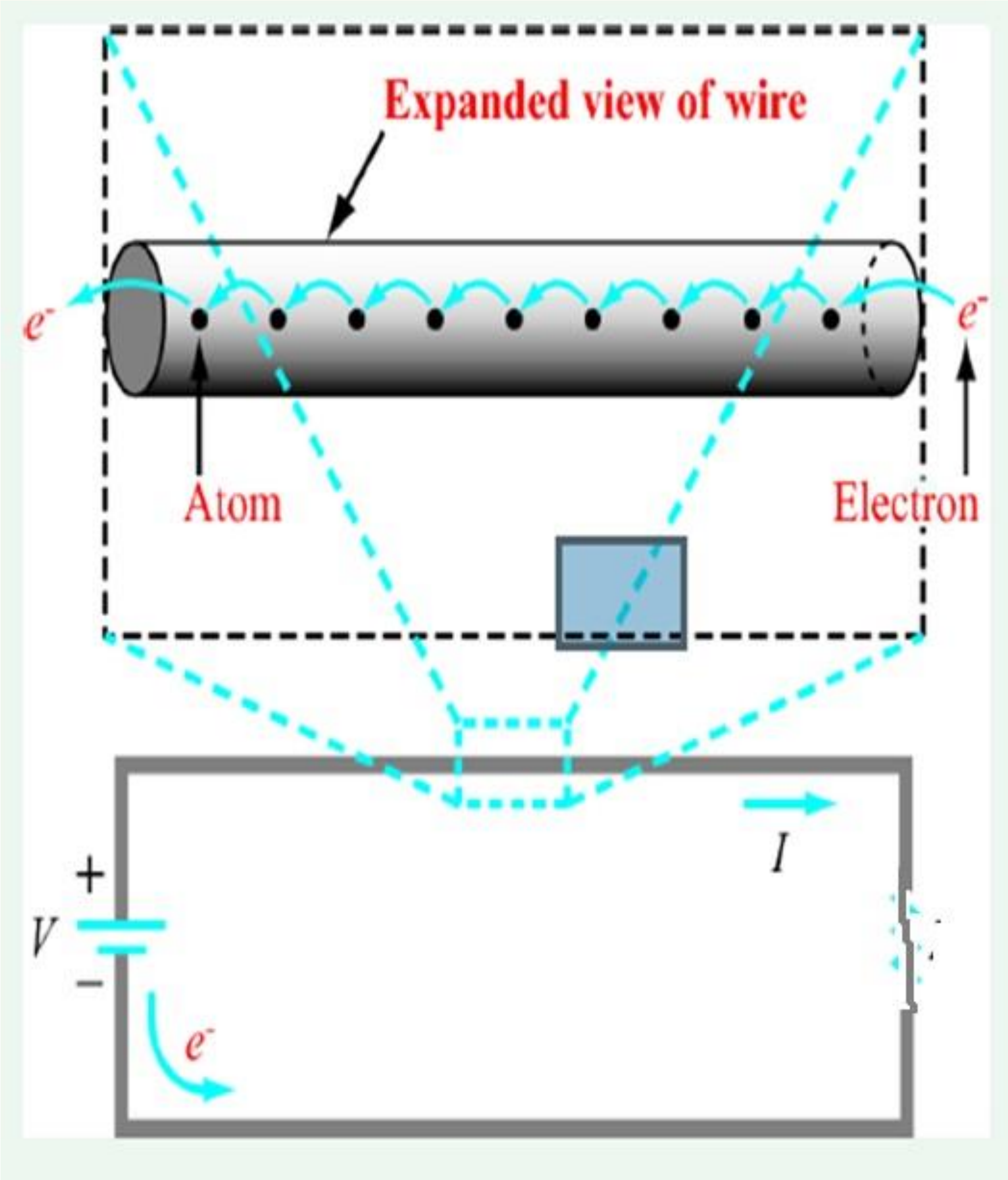
Ohm’s Law

$$R = \frac{V}{I}$$

$$Ohm(\Omega) = \frac{Volts(V)}{Amps(A)}$$

Resistance

How does electric resistance process?



Conductivity σ of a material is measurement of a measure of how easily electrons can drift through the material when an external voltage is applied across it.

Resistivity $\rho = \frac{1}{\sigma}$ $(\boldsymbol{\Omega} - m)$

- Resistivity
  - A property independent of the size of the material.
  - Resistivity is different for different materials.

Resistance

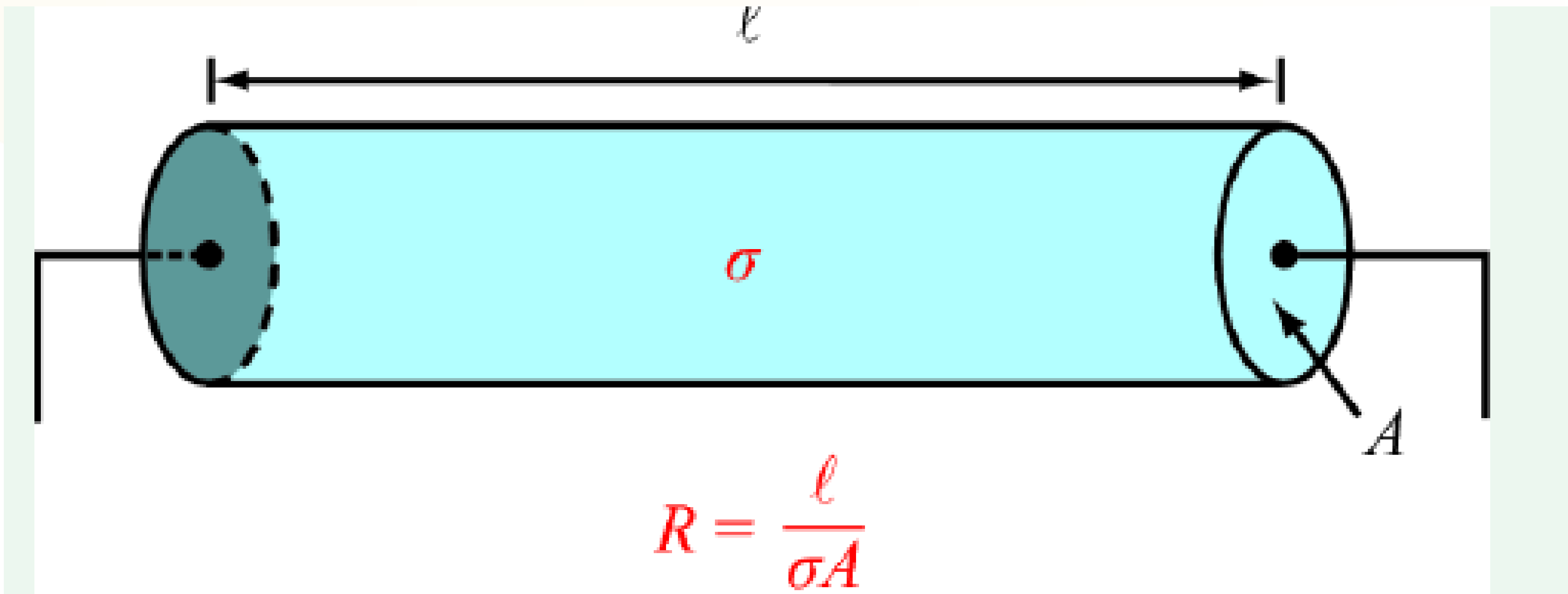
Metals Resistivity

In the table on the right the resistivity shown is with respect to that of silver. For example, gold is 1.5 times more resistive than silver, and carbon about 2000 times more resistive than silver.

CONDUCTOR MATERIAL	RESISTIVITY
Silver	1.0000
Copper	1.0625
Lead	1.3750
Gold	1.5000
Aluminum	1.6875
Iron	6.2500
Platinum	6.2500
Manganin	27.500
Carbon	2187.50

Figure 4–1 Resistance of several conductors of the same length and cross-section area.

Resistance



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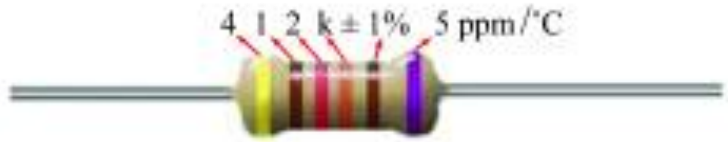
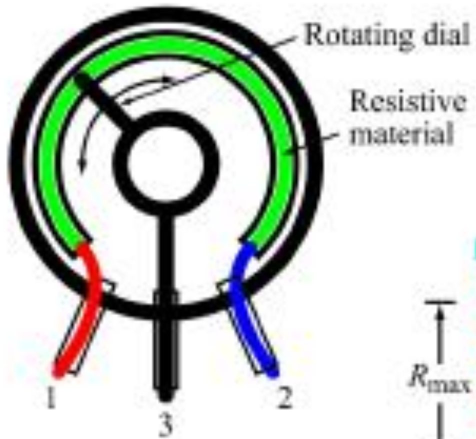
Resistance

Surface mount resistor

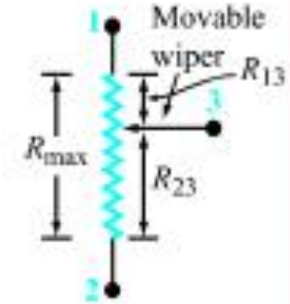
Rotatable-shaft potentiometer

Screw-top potentiometer

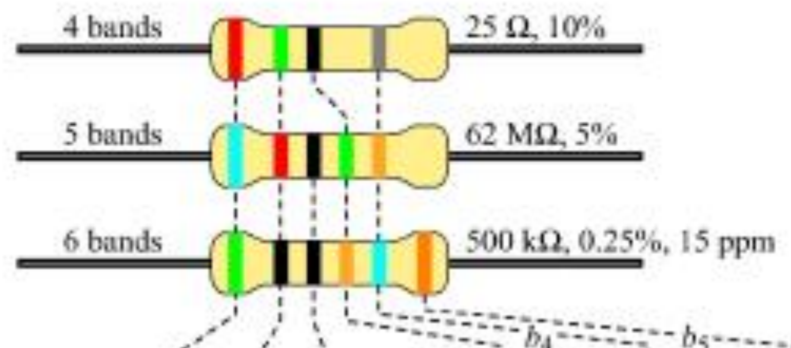




Potentiometer resistor



Potentiometer



Color	b_1 1st digit	b_2 2nd digit	b_3 3rd digit	b_4 Multiplier $\times 10^{b_4}$ # of zeros	b_5 Tolerance	b_6 Temperature coefficient ppm/°C
Silver				0.01	10%	
Gold				0.1	5%	
Black	0	0	0	1		
Brown	1	1	1	10	1%	100 ppm
Red	2	2	2	100	2%	50 ppm
Orange	3	3	3	1K		15 ppm
Yellow	4	4	4	10K		25 ppm
Green	5	5	5	100K	0.5%	
Blue	6	6	6	1M	0.25%	10 ppm
Purple	7	7	7	10M	0.1%	5 ppm
Gray	8	8	8			
White	9	9	9			

4-, 5-, and 6-band color code system

Relationship

Charge, current

$$\text{Since } i(t) = \frac{dq(t)}{dt} \Rightarrow q(t) = \int_{-\infty}^{t} i(t)dt + q(-\infty)$$

Resistant, voltage, and current

$$R = \frac{V}{I}$$

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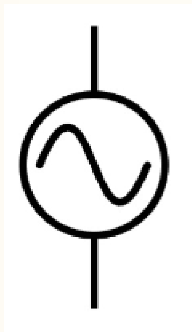
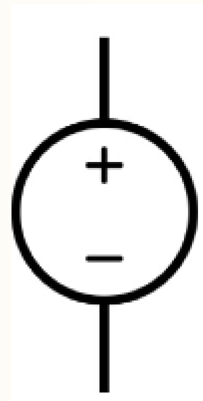
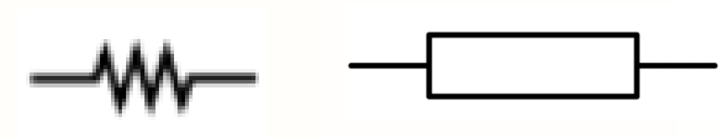
Symbols



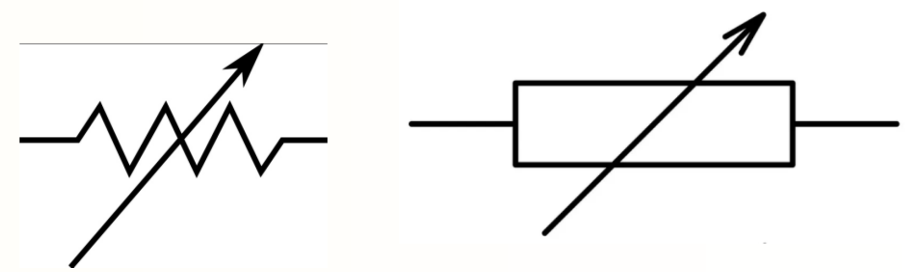
AC source



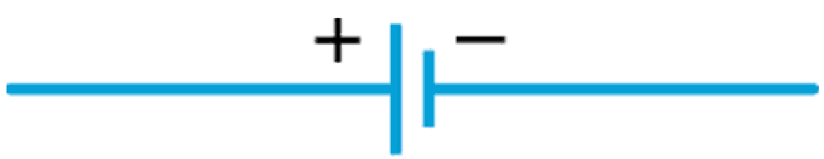
DC source



Fixed-value Resistors



Variable resistors



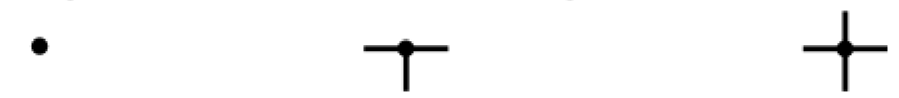
CELL

BATTERY

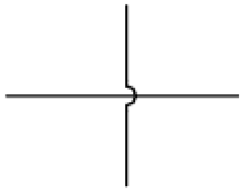
Connecting Node

3 Lines Connecting

4 Lines Connecting



Crossed but not jointed/connected



Signals and Circuits

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Power Energy Source

Text book:
Ulaby, Fawwaz T., and Maharbiz, Michael M., *Circuits*, 2nd Edition, National Technology and Science Press, 2013.
Floyd, T. L., and Buchla, D. M., *Electroics Fundamentals: Circuits, Devices & Applications*, 8th Edition, Pearson, 2009.

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Power

- Why power and energy are important in circuit analysis and design even though we have the voltage and current variables?

(1) Current and voltage are variables for electrically based systems and in many cases the output of the system is non-electrical and this output is conventionally expressed in terms of power and energy.

(2) Practical devices have limitations on the amount of power that they can handle

- Power is defined as the rate of energy exchange:

$$Power\ in\ Watts\ (w) \rightarrow P = \frac{dw}{dt} \begin{array}{l} \leftarrow energy\ in\ Joules\ (J) \\ \leftarrow time\ in\ Seconds\ (sec) \end{array} \qquad 1W = \frac{1\ J}{sec}$$

Power

$$P = \frac{dw}{dt} = \left(\frac{dw}{dq}\right)\left(\frac{dq}{dt}\right) = vi\ (W)$$

In terms of units:

$$1\ Watt\ (W) = \left(\frac{J}{C}\right)\left(\frac{C}{s}\right) = 1\ J/sec$$

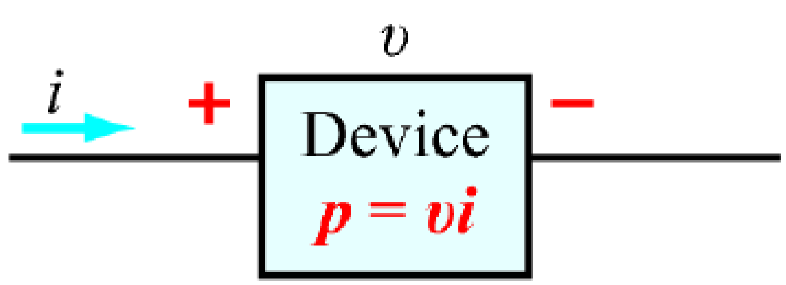
$$\Delta w = \int_{-\infty}^{t} p(t)\, dt$$

Power

- The algebraic sign of the power is based on charge movement through voltage drops and rises.

As positive charges move through a device with a drop in voltage, they lose energy(The device absorbs the energy); As positive charges move through a device with a rise in voltage, they gain energy (the device supplies the energy).

Passive Sign Convention



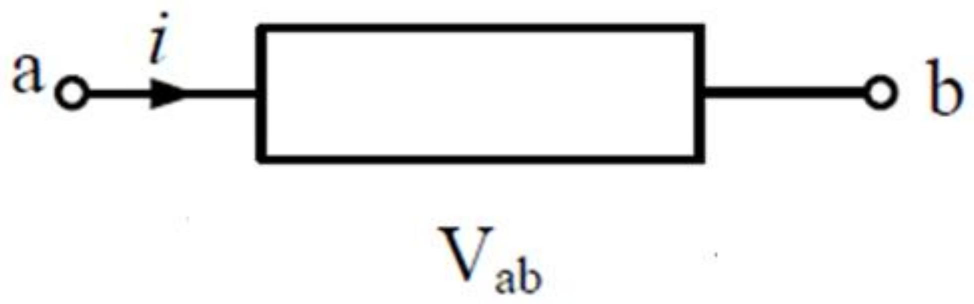
$p > 0$ power delivered to device
$p < 0$ power supplied by device

Note that i direction is defined as entering (+) side of v.

Power

Example:

Consider the following figure:

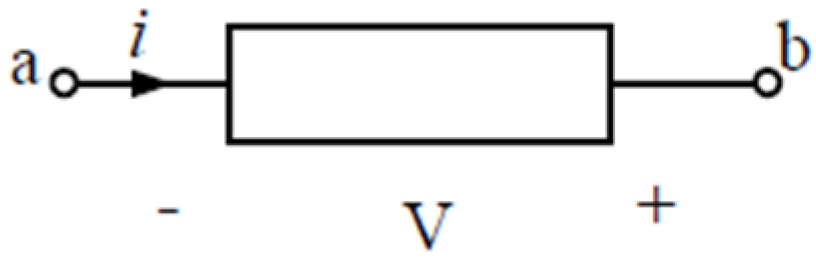


Given: i= 2 A, v_{ba} = 4 V, find the power of the device?

Given: i = 2A, v_{ba} = - 4V, find the power of the device?

Power

<u>Example:</u>



Let $v(t) = 8e^{-t}\ V, t \geq 0$

$i(t) = 20e^{-t}\ A, t \geq 0$

Find the power p(t)? Is the device a power supplier or power recipient? How much energy supplied or received over the first second of operation?

Calculate the amount of charge entering through ***a*** during the first second.

Power

Power for resistors

If a positive current is flowing through a resistor from its terminal ***a*** to terminal ***b***, is v_{ab} positive or negative?

*A resistor always absorbs power.

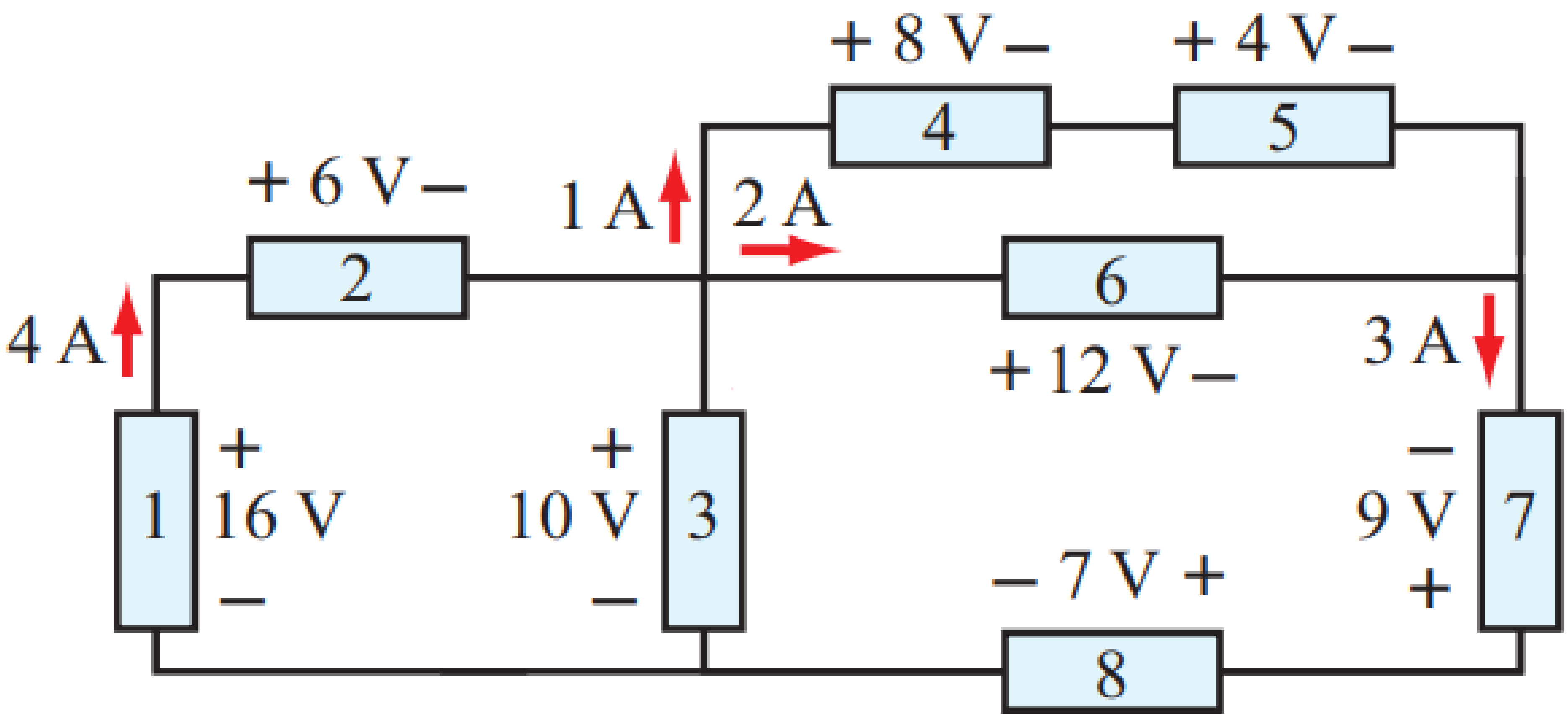
Power

The law of conservation of power requires that the algebraic sum of power for the entire circuit be always zero.

$$\sum_{k=1}^{n} p_k = 0$$

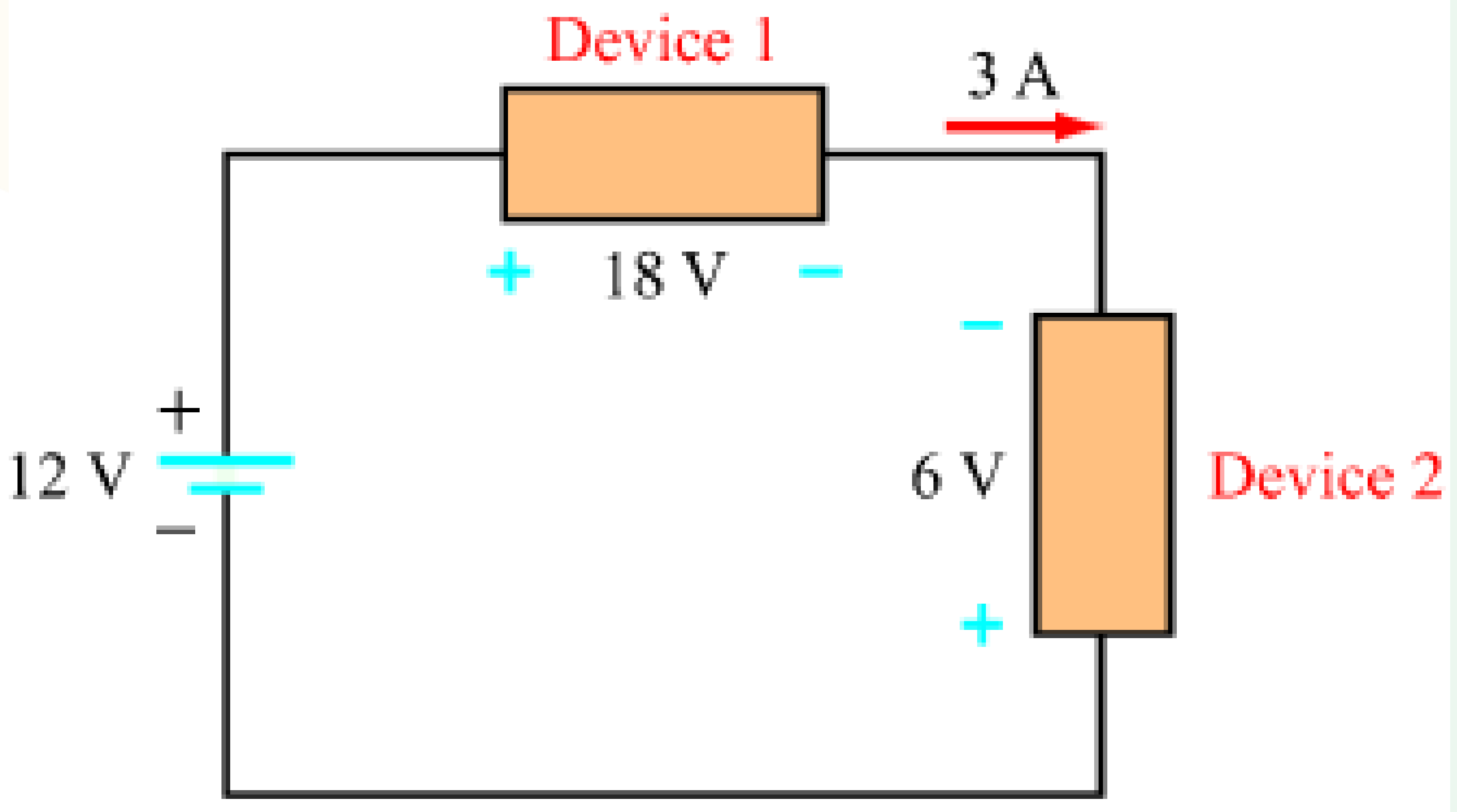
Power

Find the power for each element?



Power

Find the power for each element?



Relationship

Charge, current

$$\text{Since } i(t) = \frac{dq(t)}{dt} \Rightarrow q(t) = \int_{-\infty}^{t} i(t)dt + q(-\infty)$$

$$\Delta q = \int_{-\infty}^{t} i(t)\, dt$$

Voltage, energy

$$V_{ab} = \frac{dw}{dq}$$

Resistant, voltage, and current

$$R = \frac{V}{I}$$

Power, energy, voltage and current

$$P = \frac{dw}{dt} = \left(\frac{dw}{dq}\right)\left(\frac{dq}{dt}\right) = vi$$

$$\Delta w = \int_{-\infty}^{t} p(t)\, dt$$

Practice

The voltage across a device and the current through it are shown as following figure. Sketch the corresponding power deliver to the device and calculate the energy absorbed/delivered by it. Assume the initial charge at the beginning is 0, sketch the corresponding charge in the device at the time t.